CORRES. CONTROL
INCOMING LTR NO.

2569 RF 93

DUE DATE

ACTION

DIST.	LTR	ENC
BENEDETTI, R.L.	X	X
BENJAMIN, A.		
BERMAN, H.S.		
CARNIVAL, G.J.		
COPP, R.D.		
CORDOVA, R.C.		
DAVIS, J.G.		
FERRERA, D.W.		
HANNI, B.J.		
HEALY, T.J.		
HEDAHL, T.G.		
HILBIG, J.G.		
KIRBY, W.A.		
KUESTER, A.W.		
LEE, E.M.		
MANN, H.P.		
MARX, G.E.		
McKENNA, F.G.		
MORGAN, R.V.		
PIZZUTO, V.M.		
POTTER, G.L.		
RILEY, J.H.		
SANDLIN, N.B.		
SATTERWHITE, D.G.		
SCHUBERT, A.L.		
SETLOCK, G.H.		
SHEPLER, R.L.		
SULLIVAN, M.T.		
SWANSON, E.R.		
WILKINSON, R.B.		
WILSON, J.M.		
ZANE, J.O.		
Keith S	X	X
Boyle R	X	X
Broussard M	X	X
Ledford A	X	X
Ringle D	X	X
CORRES CONTROL	x	x

Reviewed for Addressee
Corres. Control RFP

6-15-93
DATE BY

Ref Ltr. #

States Government **Department of Energy**

emorandum

JUN 15 10 32 AM '93 **Rocky Flats Office**

EG&G
ROCKY FLATS PLANT
CORRESPONDENCE CONTROL

JUN 11 1993

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ERD:SRS:06771

Building 910 Sub Project Special Assessment Findings

Steve Keith, Acting Program Manager
Solar Ponds Remediation Program
EG&G Rocky Flats, Inc.

As you are aware, the RFO/ERD has conducted a Special Assessment by an RFO assessment team to verify the readiness status of the Building 910 Evaporator Sub project. The Special Assessment covered the disciplines of Project Management, Regulatory Compliance, Facility/Equipment Design, Facility/Equipment Operations, Facility/Equipment Testing & QA, Safety and Training. In addition RFO contracted with an independent contractor, HAZWRAP, to focus on the areas of Design, Test and Startup and Operations and to perform a limited Failure Modes and Effects Analysis (FMEA). The assessment has identified a total of 27 findings. These findings have 27 recommended actions associated with their closures. The findings and closure actions are presented in Attachment 1. A preliminary draft of the HAZWRAP report is also provided, Attachment 2. The HAZWRAP draft report is being included to provide greater detail and background for the findings that were identified by that team. This HAZWRAP draft is to be used for reference only.

Each of the findings have been grouped into one of four categories, Pre Hot SO Test Start, Pre Operations Start, Post Operations and Observations. Those categorized as Pre Hot SO Test Start must be closed out prior to the start of the Hot SO testing, likewise those categorized as Pre Operations Start must be closed out prior to the commencement of full scale operations, those categorized as Post Operations may be closed out within a reasonable period of time after the start of full scale operations. Those categorized as Observations can be acted upon at EG&G's discretion. Of the 27 closure actions, eight are designated as Pre Hot SO Test Start, nine are designated as Pre Operations Start, one is designated as Post Operations and the remainder, nine, are classified as Observations. Draft copies of these findings have already been coordinated and forwarded to your staff.

The EG&G Readiness Briefing to RFO is currently scheduled to take place on Tuesday, June 15, 1993, at 3:00 PM, in the east (main) conference room, Building 80 (Interlocken). At this briefing, the EG&G Solar Ponds Remediation Program (SPRP) Office will status the disposition of these findings and present its Evidence of Readiness Assessment to the RFO SPRP Office. If the RFO Program Office agrees with the Evidence of Readiness and feels that the assessment findings have been dispositioned satisfactorily, it will issue a Statement of Readiness letter, authorizing EG&G to commence Hot SO Testing.

ADMIN RECORD

A-OU04-000527

RF-46522 (Rev. 3/93)

JUN 1 19..

If you have any questions or require further information please contact Scott Surovchak on extension 3551 or Ernie O'Toole on extension 2699.

Scott Surovchak
Frazer R. Lockhart for
Solar Ponds Remediation Program
Environmental Restoration Division

Attachment

cc w/ Attachment:
J. Hartman, AMTER, RFO
M. McBride, DAMTER, RFO

cc w/o Attachment:
R. Schassburger, ERD, RFO
S. Howard, WOB, RFO
E. O'Toole, ERD, RFO
R. Benedetti, EG&G
R. Boyle, EG&G
M. Broussard, EG&G
A. Ledford, EG&G
D. Ringle, EG&G

BUILDING 910 STARTUP PROJECT SPECIAL ASSESSMENTS FINDINGS

NO	TITLE	FINDING	DISC	TYPE	ACTION/RESPONSIBILITY
1	Checklist no 151 & 334	The names of two employees, G. Seeley and G. Cleek are not included in the reports given as objective evidence although they have in fact received the appropriate training as evidenced by their inclusion in other reports.	Training	Observation	EG&G should pass this information on to the appropriate internal organization.
2	Lack of QA during testing	A review of the test procedures used as the objective evidence for the closure of Checklists # 35, 40, 288, 289, 292 & 293, indicates a lack of approval for real time procedure changes, incomplete test steps, lack of success criteria and missing data.	Test & QA	**Pre Hot SO Test Start.**	EG&G to show evidence as to why QA controls were not required for the performance of these tests.
3	Heat Stress	Industrial Safety Division has a concern that heat stress may be a problem for the operators who will be spending considerable time in the basement during periods of operations, as there is only one exhaust fan to provide ventilation. Ref. Checklist 102 finding.	IS	**Pre Operations Start**	EG&G should provide evidence that heat stress will not be a problem for operators in the basement of B910.
4	Drinking Water	Drinking water in plastic bottles are stored beside the nitric acid tank.	IS	**Pre Operations Start**	EG&G should store the water in another location.
5	Tripping Hazard	There is a tripping hazard in the basement near the bottom of east stairs, a platform with approx. six inch rise. Ref. Checklist 58 finding.	IS	**Pre Operations Start**	EG&G should eliminate the tripping hazard.

BUILDING 910 STARTUP PROJECT SPECIAL ASSESSMENTS FINDINGS

NO	TITLE	FINDING	DISC	TYPE	ACTION/RESPONSIBILITY
6	Pond Water Processing	Although the processing of pond water by B910 is not expected to be required, the capability to do so must be maintained. There are a number of tasks that would need to be accomplished to do so, among these tasks are the preparation of the nitric acid system, the connection of the pumps to the feedlines, evaluation of the feed prefilters, secondary containment leak detection compensatory measures, etc.	Ops	**Pre Operations Start.**	EG&G is to prepare a plan and timeline,which details the tasks to be accomplished to allow for the capability of processing pond water in Building 910. EG&G should also reevaluate it's previous testing of the system to assure that the system will work, as designed, if and when needed.
7	Checklist #192	The criteria of #192 states " Does evidence exist that shows the 910 solar pond project is in compliance with plant sampling and analytical program/plans". The objective evidence to show compliance was several pages of the IM/IRA. The proper closure should be a comparison of the actual product water sampling plan, 22-PWSP-910-012 with the requirements contained in the IM/IRA and with plant sampling and analytical program/plans.	T&QA	**Pre Hot SO Test Start.**	EG&G should revalidate the checklist by a comparison of the Product Water Sampling Plan to the IM/IRA and plant requirements.
8	Self Assessment Process	In general the self-assessment process employed by the SPRP focuses on process validation rather than process implementation. The vast majority of the checklists deal with whether or not a piece of paper has had the proscribed review and signatures rather than validating whether or not the piece of paper has been implemented properly.	PM	Observation	EG&G should revamp the self-assessment process to focus more on process implementation rather than validating that the processes are in place.
9	Cross Contamination of Domestic Cold Water With Distillate	Ref. P&ID # 39365-007. The distillate is connected to the domestic water line with back flow preventors. This is a potential source of contamination of the domestic water system.	Design	**Pre Hot SO Test Start.**	A fix is already in work by EG&G. EG&G needs to complete the work specified under EO 35599 prior to Hot SO startup.

BUILDING 910 STARTUP PROJECT SPECIAL ASSESSMENTS FINDINGS

NO	TITLE	FINDING	DISC	TYPE	ACTION/RESPONSIBILITY
10	Sight Glass on EDTA Day Tank	The EDTA tank has a high and low level sensor. During start up it will be difficult to monitor the liquid level because of large variations in EDTA requirements. A sight glass needs to be on the tank to permit the continuous monitoring of the EDTA level.	Design	**Pre Hot SO Test Start.**	EG&G is currently installing a sight glass on the EDTA tank under FD340. This needs to be completed prior to Hot SO test start up.
11	Watchdog Timer	The Programmable Logic Controller (PLC) provided by Licon has a Watchdog Timer, but an indication of its status is not readily available to the operators.	Design	**Pre Operations Start**	EG&G shall provide a means to enunciate the status of the watchdog controller to the operator prior to operational status
12	Power to the PLC	Power to the Licon provided PLC is provided by the unit generator. Shutdown or failure of the generator can result in the shutdown of the evaporators to an unknown condition, recovery from which could be extremely time consuming and could possibly lead to contamination of clean systems or areas external to the evaporators.	Design	Post Operations	It is recommended that EG&G place the PLC on house power and that all other instruments and control circuits be placed on house power.
13	DOE Order 6430.1A Compliance	The Licon provided equipment does not appear to be in compliance with DOE Order 6430.1A in the areas of Fail Safe Alarming, Positive Confirmation of Alarms and Alarm Testing, (Details are contained in the attached DRAFT HAZWRAP report)	Design	**Pre Operations Start**	EG&G is to: 1) evaluate the applicability of the Order to the off-the-shelf GFP Licon evaporators, and 2) evaluate the HAZWRAP concerns on their own merit and provide recommendations for their disposition.
14	Engine Cooling Water Control	The manual valve used on the current design of the engine jacket cooling water must be constantly adjusted by an operator during startup.	Design	Observation	EG&G is to consider retrofitting this system with an automatic system.

NO	TITLE	FINDING	DISC	TYPE	ACTION/RESPONSIBILITY
15	EDTA Feed System	The EDTA feed system design does not follow the manufacturer's recommended installation, in that the system did not incorporate a "mixing tee". There is a concern that the system as designed will not provide a homogeneous mixture which could cause excessive scaling. There is also a concern that if the mixture is not homogenous, the EDTA curves that are to be generated during the Qualification Testing would not be adequate.	Design	**Pre Hot SO Test Start.**	EG&G is to evaluate the current design and provide evidence that there is sufficient mixing downstream of the EDTA injection point to mitigate the stated concerns.
16	Nitric Acid Feed System	As designed, the Nitric Acid feed system does not have a double block and bleed system to prevent an accidental discharge during system repairs. Also the monitoring of acid level in the tank would be enhanced by the installation of a sight glass. In addition, P&ID 39365-019 shows a remote flowmeter-pulser, FE823. This FE has a bronze/brass body. It shoukd be investigated to determine if it is suitable for the purpose intended.	Design	Observation	Since the present operational plans for Building 910 do not call for the use of the Nitric Acid System, EG&G should factor these observations into any future use of the system. These items should be factored into the planning and timeline required in Item # 6 above.
17	System Leaks	All three evaporator systems have experienced numerous leaks at all types of joints and connections. EG&G has implemented corrective actions that are nearing completion. It is not certain at this point that a leak free system, required by regulations will be attained by Hot SO Test start up.	Design	**Pre Hot SO Test Start.**	EG&G will provide a leak free system by Hot SO Test Start or provide evidence that the leaking has been minimized by providing details of the efforts conducted to eliminate the leaks, a status of the current leaks within each system, including the number of leaks, approximate volumes of fluid leaking, the type(i.e. feed, distillate or brine) of fluid leaking. EG&G will also provide a plan as to how and when it will achieve a leak free system.

NO	TITLE	FINDING	DISC	TYPE	ACTION/RESPONSIBILITY
18	Preventative Maintenance	The performance of the MEMS stages over time requires some evaluation. The condensers could become a problem with scaling or fouling because of inadequate feed treatment. There is presently no provision for cleaning the condenser tubes without removing the condenser from the system.	Design	Observation	EG&G should consider the use of the nitric acid system for treatment of the ITS feed to help miinimize maintenance due to scaling.
19	Multiple Meaning for Indicators	Because of the present power configuration (Ref. Item # 12 above) and because there are no provisions for alarm testing or fail safe alarming (Ref. Item #13 above), each display indicator can have four possible modes: (1) normal energized state, (2) normal de energized state, (3) burned-out light state, and (4) no power state.	Design	**Pre Operations Start**	EG&G should account for these multiple meanings for the alarms within the operations procedures and operator training.
20	PLC Ladder Logic Configuration Control	The PLC Ladder Logic has been in the hands of Licon up till now. There is at present no configuration control of the PLC Logic.	PM	**Pre Operations Start**	This PLC Logic should be brought under EG&G configuration control
21	Pressure Gage Installation Detail	The pressure gages for liquid service are installed above the level of the liquid lines on the vapor compressor evaporator. If the units are down for a period of time, air could enter the system, requiring purging. Purging the instrumentation lines after start up could expose the operators and the environment to contaminants which would require special precautions and increase maintenance time.	Design	Observation	EG&G may want to install purge lines for these gages such that they do not have to be purged into the open.

NO	TITLE	FINDING	DISC	TYPE	ACTION/RESPONSIBILITY
22	Signet Flow Meter Installation	The signet flow meters are mounted vertically in the Licon system. Vertical mounting reduces the accuracy of the measurements. The manufacturer recommends that they be mounted horizontal.	Design	**Pre Operations Start**	This item has been discussed with the EG&G operations people and they have concluded that the accuracy of the measurements emanating from these flow meters does not impact efficient operation. EG&G should document the reasons why there is no impact.
23	Redundant Power and Air Systems	There is no backup to generator electrical power, house electrical power or instrument air to the evaporator system.	Design	Observation	With the long startup times involved on restarting the units, it may be economically advantageous to have redundant systems in place for electricity and instrument air.
24	Testing and Calibration of I&C Systems	The calibration of instrumentation for the evaporator system has not been completed.	Test & QA	**Pre Hot SO Test Start.**	EG&G must complete the calibration of the evaporator systems instrumentation prior to Hot SO Test Start.
25	Safety Hazard	It was noticed that a pipe rack I-beam between Generator 3 and Building 910 is mounted so that tall persons may hit their heads.	IS	Observation	EG&G should evaluate the situation and determine if the situation constitutes a safety hazard, and if so take appropriate action.
26	Process Qualification Procedure	The Process Qualification Procedure, Document No EO 34575. The HAZWRAP assessment team has provided comments to the above document. These comments are contained in pages 12 through 14 of the attached draft HAZWRAP report.	Test & QA	**Pre Hot SO Test Start**	EG&G shall review and incorporate or otherwise disposition the attached comments in conjunction with the RFO SPRP program office.
27	Factors That Will Reduce Throughput	The HAZWRAP assessment team has provided comments that could enhance the performance of the evaporators. These comments are contained in pages 14 and 15 of the attached draft HAZWRAP report.	Design	Observation	EG&G should review and evaluate the attached comments and incorporate those that are practical and within the constraints of present schedules and budgets.

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June 7, 1993

Ernie O'Toole

Building 910 Evaporators/Modular Tanks Startup-Rocky Flats Plant

Hazardous Waste Remedial Actions Program (HAZWRAP) staff visited the site from May 11 through May 14, 1993, and May 24 through May 28, 1993. The first trip was undertaken by R. C. Chopra and S. J. Senatore to collect information and data. On the second trip, in addition to the two former staff members, R. Van Winkle, F. R. Ruppel, and D. D. Holt also visited the site.

Through discussions with Rocky Flats personnel during these visits, it was determined that the Scope of the Work assignment has been modified from what was originally envisioned. This modification is primarily because of the delay in receipt of notice to proceed and the resultant change in progress at the time of our arrival.

Note that current plans for the evaporator trains no longer include processing solar pond water. Only interceptor trench water will be processed within the facility. The nitric acid feed system intended to control pond feed water pH will not be needed and will not be tested as part of system startup. In the event that this changes, a procedure for checkout and startup of the nitric acid feed system must be developed and implemented.

We have been asked to confine the review to design items that could hold up the start of the Qualification Testing and Operational Status. Similarly, the Failure Modes and Effects Analysis (FMEA) portion of the assessment is to be directed so that no single failure or combination of two failures could lead to the deposition of feedwater into the raw water or condensate systems and so that we may identify failures that could lead to excessive down time.

A summary of the HAZWRAP Team's initial observations and findings at the site follows.

IMMEDIATE CONCERNS

- **Cross Contamination of Cooling Tower Water by Feed to the Evaporator**
  The cooling tower blowdown, as presently piped, is sent to the evaporator feed for further concentration. The pressure in both lines is about the same. However, the flows could reverse, and the feed to the evaporator would get into the cooling tower circuit and contaminate the cooling tower system. It has been proposed that the connection of the blowdown line to the evaporator feed be eliminated to avoid this possibility. We concur with this recommendation.

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- **Cross Contamination at Concentrate Circulating Pump In the Multieffect/ Multistage Flash Evaporator (MEMS)**
  The pump seals are lubricated with distillate. The pressure at the seal is similar to the concentrate pressure inside the pump; therefore, backflow can occur and allow the concentrate liquid to bleed back into and contaminate the distillate system. All the pump seals are being replaced. The distillate will be monitored by a conductivity meter to detect cross contamination.

- **Cross Contamination of Domestic Cold Water with Distillate**
  See Piping & Instrumentation Diagram Distillate Distribution System drawing No. 39365-007. The distillate connected to the domestic water line with backflow preventer is a potential a source of contamination of the domestic water system. Normally an air break in the line is required for this type of application.

  Solution: Install a separate line to use the distillate as cooling tower makeup or provide a tank rather than one line as in the present arrangement.

- **Metallic Cover On Control Box**
  The startup of Licon gas engines requires close control between the engine cooling water flow and the recycle flow during the startup mode. Currently the manual bypass valve is beyond reach of the flowmeter. Safety requires the cover to remain closed except when reading the recycle flow. Therefore, it is difficult to respond rapidly in manually changing the recycle flow rate. The metal instrument cover is being replaced with a plexiglass cover to permit visual inspection without having to open the flowmeter; hence, a more rapid response can take place in manually controlling the recycle flow.

- **Expansion Joint**
  The flexible pipe connector between the engine cooling water and the engine is a short horizontal piece. This pipe is insufficient to absorb both shock resulting from vibrations and thermal expansion during startup or cooling down. A U-shaped expansion loop is being installed as recommended by Caterpillar. We concur.

- **Sight Glass on EDTA Day Tank**
  The ethylenediaminetetraacetate (EDTA) tank has a high- and low-level sensor. During startup it is difficult to monitor the liquid level because of large variations in EDTA requirements. The solution to this problem is the installation of a liquid sight glass on the tank to permit the continuous monitoring of the EDTA level. The sight glass is currently being installed.

- **Natural Gas Venting**
  The Final Safety Analysis Report, Building 910, EG&G Rocky Flats reports that a mitigating function to avoid natural gas accumulation in the generator enclosure because of a valve, pipe, or connector leak during ignition, operation, or standby is the enclosure roof-mounted turbine exhaust fan. When we inspected the generator enclosure, we noticed that the turbine vent was taped over because it made the enclosure too cold for

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an operator during cold, winter operation. It is recommended that administrative controls be placed on not taping the turbine vent closed and that a more comfortable, heated environment be provided for the generator operator.

Note: Unlike information reported at the assessment out-briefing meeting May 28, 1993, the National Fire Protection Association (NFPA) code does not require double block and bleed valves for natural-gas-fueled generators; this requirement is for natural-gas-fueled industrial boilers. If a diaphragm-operated fuel shutoff valve were used, the NFPA code would require a bleed on the generator fuel line. However, a diaphragm-operated valve is not used; therefore, it is not necessary for the generator fuel line to contain a double block and bleed valve arrangement.

- Watchdog Timer on the Programmable Logic Controller
  The programmable logic controller (PLC) provided by Licon controls system interlocks and operating sequences. If the PLC is locked up, the interlocks and operating sequence will not function. It is recommended that a watchdog timer be used on the PLC to notify the operator when the PLC has ceased to operate. The PLC does have a watchdog timer, and its status is available on one of the PLC status indicators. However, this indicator status is not obvious to the operator. (The PLC is located behind closed cabinet doors.) It is recommended that either an alarm or shutdown be activated when the PLC watchdog timer activates.

- NFPA 37 Engine Protection Devices
  NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, calls for the following engine protection devices on engines of 100 horsepower or more:

  - An automatic engine shutdown device for high jacket water temperature or high cylinder temperature,
  - An automatic engine shutdown device for low lubricating oil pressure,
  - An automatic engine shutdown device for engine overspeed,
  - An automatic engine shutdown device for high lubricating oil temperature,
  - Some means of shutting down the engine at a readily accessible location remote from the engine,
  - A remote means of shutting off the fuel supply, and
  - A remote means of shutting down lubricating oil pumps not directly driven by the engine.

  Some of these items were observed to be in place during our site visit, but the

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NFPA standard was not on hand at the time, so compliance with all the items was not addressed. Time has not allowed investigating all these items since our return, and some of the logic drawings on the system are faded. Therefore, compliance with all the items has not been confirmed. Please confirm compliance with the standard.

- Power to PLC
  Having the PLC powered by the generator is a reliability concern. Power from the generator will not be clean. Although a power conditioner is used between the generator and the PLC, the conditioner will not be able to deal with interruptions in power. Microprocessor-based devices such as the PLC are susceptible to glitches in power, which can cause the PLC to lock up. An argument for using generator power for the PLC is that, if there is a power failure, the process would shut down for lack of power and the PLC would not be needed because the system would shut itself down. However, the PLC is more sensitive than processing equipment, and it can easily lock up while the process equipment continues to operate. In addition, the failure mode of the PLC system outputs is not certain. Outputs to valves and other equipment could fail in either the energized or de-energized state; therefore, it is not possible to make the system failsafe for a PLC lockup. Unlike originally conceived, house power is now available for use by the PLC. Although spare 120-V circuits may not be available, a transformer to convert from 480 V to 120 V is available. It is recommended that, as a first step, the PLC be placed on house power, rather than generator power. As a second step, all other instrumentation and control circuits should be placed on house power. (See also section entitled The Multiple Meaning for Indicators.)

DEPARTMENT OF ENERGY COMPLIANCE CONCERNS

- Fail-Safe Alarming
  The standard accepted practice in industry for alarm fail safety is to have the alarm circuit energized (current flowing) in the normal state and to go to the deenergized state during the alarm state. In this manner, if a problem exists in the alarm circuit itself, the alarm will sound and notify the operator that a problem exists with that circuit. It does not appear that this failsafe alarm methodology has been adhered to in the Licon design (although it has been in the EG&G design). For example, see temperature switch TSH-806, compressor high oil temperature interlock, on drawing 39365-7401. The temperature switch is shown normally open, which means that the circuit is open in the normal (nonalarm) state. If there is a break in this circuit, there is no indication to the operator; furthermore, the alarm would not actuate during the high-temperature alarm condition. It is recommended that the Licon-designed alarms be made consistent with the EG&G-designed alarms and use the failsafe alarm circuit methodology.

- Positive Confirmation of Alarms
  DOE order 6430.1A, Section 1300-12.4.8, states that "Provision shall be made for maintaining personnel awareness of alarm conditions until they have been corrected or

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cleared. Clearing of the alarm shall require positive response from the assigned personnel." It should not be allowed for an alarm to occur and clear itself. Most alarms on the Licon system also cause a shutdown, so this in effect is a means of latching the alarm. However, there does appear to be nonshutdown alarms, such as the seal water low flow alarm on drawing 39365-7401, which alarms but does not shut down the system. It appears that this alarm can occur and clear itself with no positive response from the operator. (EG&G-designed systems feed into a Panalarm annunciator, which probably latches the alarm, thus requiring positive action by the operator. However, this was not confirmed during the site visit.) It is recommended that a latching circuit be installed such that all alarms require a positive response from the operator before being cleared.

- Alarm Testing
  DOE order 6430.1A, Sect. 1300-12.4.8, references NUREG 0700 Sect. 6.3 for warning and annunciator systems. NUREG 0700, Sect. 6.3.4.1, calls for a test sequence for alarms. The Licon-designed systems do not appear to have an alarm test procedure. (EG&G-designed systems feed into a Panalarm annunciator, which probably has a test sequence, although this was not confirmed during the site visit.) Most but not all of the alarms on the Licon equipment will be in effect when the unit is started, and this will serve as a means to check alarm circuits during startup for those alarms that are in effect. However, the other alarms that are not in effect cannot be checked, and more importantly, there is no means for the operator to check any alarms when the unit is operating. It is recommended that an alarm test circuit, which can easily be activated by the operator, be installed on all alarm systems.

- Human Factors
  DOE Order 6430.1A, Sect. 1300-12.2, states "Enhancements to the work environment and human-machine interfaces will reduce human error and its consequences and lead to increased productivity, lower costs, better product quality, decreased equipment and property damage, improved program schedules, personal job satisfaction, and, perhaps more important, to further improvements in the safe operation and maintenance of DOE facilities."

  Section 1300-12.4.1 states "The organization of operator movements and the arrangement and accessibility of equipment and controls in the work area shall facilitate convenient access to each system component for operation and maintenance."

  The manual valve used in the current design of the jacket cooling water must constantly be operated by an action of the operator during startup. It is recommended that an automatic valve retrofit be considered for this application as well as any other means to lessen the operator's burden of starting up the generator system.

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REVIEW OF OTHER ASPECTS

- Change Orders and Field Directives
  Approximately 240 Engineering Change Orders (COs) and Field Directives (FDs) were reviewed. These COs were issued to remove the then-existing equipment in Building 910, install new foundations and berms, correct dimensions, and provide electrical or mechanical technicians to the vendor for testing the equipment under the vendor's supervision. HAZWRAP did not discover any CO that will significantly affect operation of the system. In general these FDs were concerned with rerouting of lines to correct for equipment interferences and dimensional errors. None were found that would adversely impact the readiness for operation of the System Operation (SO) test program if the work described was accomplished satisfactorily. A few FDs were to correct for miscellaneous deficiencies in items received from Licon. In FD-203, the tubing material supplied for hookup of the nitric acid pumps P-26A and B was unsuitable for nitric acid service but would be used in the SO test with water if acceptable replacement stainless steel tubing were not received before the test.

  HAZWRAP does not certify the accuracy/legitimacy of the dimensions or the COs/FDs. HAZWRAP has looked at these FDs/COs from the point of view of suitability for use in the application.

- Use of Copper and Copper Bearing Alloys
  It appears that copper or copper bearing alloys have not been used anywhere in the facility except as pointed out below.

  The feed water into the evaporators is high in nitrates (1085.5 mg/L, Specification for a Portable Evaporator System). Nitric acid is used for adjustment of pH in the feed water from a range of 11-12 to 7.5-8.0. Copper and copper bearing alloys are acceptable but not recommended for service in this application wherever the liquids can come in contact with the metals. As a good engineering practice, copper and copper bearing alloys should not come in contact with other metals such as stainless steel.

  P&ID 39365-019 shows a remote flowmeter-pulser, FE 823. This FE has a bronze/brass body and it should be investigated to determine if it is suitable for the "purpose intended."

- Degradation of PVC Material due to Radiation
  The maximum gross alpha and beta concentrations (pCi/L) reported are 2107 and 886 respectively. These concentrations could go up by a factor of 25 in the evaporator bottoms. It does not appear that these concentrations will cause appreciable PVC degradation as a result of radiation.

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- EDTA Feed System
  Piping & Instrumentation Drawing 39365-019, Rev. B, April 2, 1992. The concentrated EDTA solution is being fed directly into the evaporator feed line. The manufacturer's recommended installation details do not appear to have been followed. No "mixing tee" is present, and no check valves are in the lines at the EDTA feed line connection. We concur with the findings (Observation number 9) of the Design Review Report, April 15, 1993. There should be a "mixing tee" or, as a minimum, a static mixer downstream of the injection point for proper distribution of the EDTA. The EDTA feed system can be automated by installation of an in-line probe. This will be a system enhancement.

- Nitric Acid Feed System
  The system is used to adjust the feed pH when feed is from the solar ponds. The pH is adjusted downwards in the range of 7.5 to 8. The nitric acid pH mixing tank D-56 has a total volume of 300 gal. It has a LAHH, LAH, LAL, and LALL on the tank. This single system feeds all three evaporator trains. Each train has a feed capacity of 13.3 gpm, providing a combined capacity of 39.9 gpm for the three trains. The pH mixing tank has a holdup time of 7.5 minutes.

  The liquid level should be more closely monitored during system startup and during system treatment than is possible with the existing level indicators. It would facilitate monitoring if a liquid level sight gage were installed on the D-56 tank.

  Piping & Instrumentation Drawing 39365-020, Rev. A, March 30, 1992. A double block and bleed system is usually provided downstream of the pump discharge to avoid any accidental discharge during pump or other system repairs. It is also desirable to be able to bleed down the system to avoid static concentration of nitric acid in the system piping when the evaporator system is not in operation.

- Threaded Connections Between Dissimilar Materials
  It is not considered good engineering practice to have threaded connections between dissimilar materials in applications of this nature. Because of the difference in thermal expansion rates, joints between PVC and metal pipes are prone to leak. All threaded connections between dissimilar materials should be changed to flanged connections with full-face gaskets using a PVC flange on the PVC pipe.

  During our visit during the week of May 24, 1993, it was observed that all threaded connections between PVC and stainless steel are being changed to flanged connections. This should eliminate most of the leaks that have been observed during the past run.

- Generator Units
  The jacket cooling water flow is essential for engine operation. Entrapped air or reduced cooling water flow (below 120 gpm) can cause overheating and engine

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seizure. The procedure for venting of air in the jacket cooling water circuit must be carefully reviewed. The impact of potential failure of the cooling water circulation pumps (P-3004 on each train) during operation must also be reviewed. **A failure modes and effects analysis (FMEA) has been prepared on this flow circuit, and a detailed analysis will follow.**

The jacket cooling water supplied from the multieffect/multistage flash evaporator (MEMS) proceeds through the heat recovery silencer then returns to the MEMS electric heater HC-3008. This heated water then flows to the Stage 1 concentrate heat exchanger and returns either directly to the expansion tank D-3007, or if some added cooling is required, passes first through the engine flat plate auxiliary cooler E-3003. This exchanger is cooled by the auxiliary cooling tower located outside Building 910. The expansion makeup tank D-3007 is also fed from the engine jacket water for venting through PSV 825. It is this flow circuit, with the bypass around the concentrate heater and the auxiliary cooler, that must be carefully monitored.

No pump is shown in the aftercooler flow circuit; however, the turbocharger has its own water circulating pump. The turbocharger can readily fail without cooling water because of overheating expansion and rubbing.

Note that a slight gas leak inside the engine enclosure can become disastrous if the enclosure turbine exhaust fan fails to operate. A natural air enclosure ventilating cycle should be provided for safety.

- Multieffect/Multistage Flash Evaporator Transvap 750
  The MEMS system operates in the following manner. Concentrate from the vapor compressor (VC) enters the Stage 2 flash chamber at about 35,000 ppm total dissolved solids (TDS). The flash chamber operates at 170°F. The vapor generated in Stage 2 is condensed in the second-stage condenser. The reject is pumped through the Stage 1 condenser and heated additionally in the concentrate heater by the engine cooling water. This reject is then fed to the Stage 1 flash chamber. The vapor generated in Stage 1 is fed to the first-stage condenser. The distillate is fed to second- and third-stage condensers for heat recovery. At each stage, the feed to that stage is heated by the stage vapor condensing and the distillate from the preceding stage. The Stage 3 feed is made up of the reject from Stage 2 and from the Stage 3 reject which is reheated by the Stage 2 condenser. The reject from Stage 3 can also be pumped into the basement sump (concentrate tank). The feed to Stage 4 is recycled through Stage 4 after the Stage 4 reject is reheated in the Stage 3 condenser. Some Stage 4 reject goes into the concentrate tank. The vapor produced in Stage 4 is condensed in the Stage 4 reject condenser by cooling tower water. The pond water feed goes through the feed heater then goes to the VC unit. The feed heater is supplied by some vapor from the Stage 4 flash chamber. The condensate from this feed heater goes to the distillate tank D-4008.

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Difficulty has been experienced in preventing leakage of the reject flows at the circulating pumps on each stage. The primary cause appears to be the alignment of the motor to the pump itself. Some degree of misalignment causes the seals to wear excessively. An improved alignment kit is very desirable to minimize this problem. The pumps have also been dry for an extended period which has probably caused the seals to dry out and leak. There are many water leaks where PVC or chlorinated polyvinyl chloride (CPVC) piping is screw-threaded into steel piping. The large difference in thermal expansion between steel and PVC piping during the heatup or cooldown cycle is a root cause of this leakage. (The threaded connections with dissimilar materials are being changed to flanged connections as of May 28, 1993.)

The performance of MEMS stages over time requires some evaluation. The condensers could become a problem with scaling or fouling because of inadequate feed treatment. There is no provision for cleaning the condenser tubes without removing the condenser from the system. Because the system is under vacuum, sources of inleakage must be monitored and controlled or condenser fouling will occur.

- Vapor Compression System

The primary concern with the vapor compression system is the heat transfer performance of the VC-500 evaporator with time of operation. The vapor generated in the evaporator is supplied to the vapor compressor after passing through the demister. Some distillate from the distillate tank D-4001, after passing through the feed heater and the distillate cooler, is sprayed into the evaporator vapor being fed to the Roots Compressor. Normally the liquid is used to desuperheat steam at the compressor discharge. The system design indicates that in this case the liquid is, instead, sprayed at the inlet of the VC. The manufacturer does not want any superheated steam in the compressor and, therefore, wets the steam at the inlet. Wet steam being fed to the compressor can cause erosion of the compressor rotor. The compressor should be monitored for this possibility.

The compressor work can be calculated knowing the enthalpy of the steam entering and discharging from the VC. Thus, if the steam flow rate is known, the efficiency of the VC can be estimated using the electrical input to the compressor drive. The motor efficiency must be accounted for in calculating the VC input power. This calculation should be made occasionally to monitor the VC efficiency.

The VC discharge enters the condenser tube area between the titanium tube and the plastic bayonet insert. As the steam proceeds down the length of the tubes it condenses, giving up its latent heat of vaporization, causing boiling of the feed water in the evaporator. The condensed steam distillate returns to the incoming tube bundle end through the inside of the bayonet and then drains into the distillate tank.

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Steam generated in the evaporator, which surrounds the condenser tube bundle, is fed to the VC inlet. The preheated incoming feed from the MEMS condensers goes to the concentrate tank D-6001 and is also sprayed into the top of the evaporator to enhance vapor generation and to prevent scale buildup on the condenser tubes above the liquid level. Depending on the amount of flooding attained by the spray, scaling or fouling of the tubes could occur, and the tubes could become less efficient as a result of the accompanying deviation from the designed heat transfer coefficient (U) value.

The possibility of fouling the condenser tubes increases as the concentration increases in the D-6001 tank. Level controllers regulate the concentrate in Tank D-6001. When the concentration reaches a predetermined level, the concentrate is drained to the concentrated brine storage tank in the basement . The concentrate level in D-6001 is maintained with the incoming feed from the MEMS. Any accidental overflow in the tank will result in drainage into the basement sump. The blowdown from the VC-500 evaporator goes to the MEMS second-stage inlet at a concentration of about 35,000 ppm total dissolved solids (TDS).

Using the concentrate tank D-6001 as both the feed stream and reject increases the hazard of evaporator fouling. This design cannot be changed with the existing equipment; however, caution is advised. A program should be established for monitoring the overall heat transfer coefficient of the titanium tube bundle.

INSTRUMENTATION AND CONTROLS COMMENTS

- Multiple Meaning for Indicators
  Without a means to test indicators, it has to be assumed that an indicator that is off means the equipment is not on. But because power can be off to the indicator, it can also mean that no power is on to the indicators. Therefore, each generator-powered panel display indicator will now have four possible modes: (1) normal energized state, (2) normal deenergized state, (3) burned-out light state, and (4) no power state. Implementing the recommendation in the section entitled Power to PLC will reduce the possible modes to three and implementing the recommendation in the section entitled Alarm Testing will provide a means to determine whether an indicator is burned out.

- Generator Battery
  A couple of references were found to the generator battery being dead before system testing. When the system is not used on a regular basis, this can be expected to happen, especially in the cold climate of Colorado. It is suggested that, if sporadic usage of the generators is expected in the future, some type of permanent battery-charger circuit be installed.

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OTHER CONCERNS AND ASSESSMENTS

- Alarm Response Procedures
  Alarm response procedure 4-22ARP-101-MEMS, page 5, calls for checking PLC channels 13, 21, and 2 in the event of a high-temperature alarm. This should probably refer to data scanner channels 13, 21, and 2. Status of inputs to the PLC should not be considered part of an operator's normal routine, because it takes a trained person to perform this either by observing the PLC hardware or by connecting a personal computer to the PLC and observing the ladder logic status.

- PLC Ladder Logic Configuration Control
  PLC ladder logic has been in the hands of Licon up until now. There should be a documented configuration control procedure at Rocky Flats once the code is officially turned over to the plant.

- Pressure Gage Installation Detail
  Pressure gages for liquid service were noted and they are above the level of the liquid lines on the vapor compressor evaporator. It is necessary to purge these lines of bubbles when the units are first started up. As long as the vapor compressor evaporator is not drained, it is not necessary to purge these lines. If the vapor compressor were under repair, the system were drained, it is assumed that the system will be purged with domestic water before startup. Purging the gage lines with pond water would expose the operator and operating area to the pond water. It may be necessary to install special purge lines for these gages such that they do not have to be purged into the open.

- Signet Flow Meter Installation Detail
  The Signet paddle flow meters are mounted vertically. The owner's manual recommends not doing this. It says "Vertical mounting of the flow meter runs the risk of having either air bubbles or sediment interfere with the continuous action of the paddle wheel." Side mounting is most desirable.

- Redundant Power and Instrument-Air Systems
  There is no backup to generator electrical power, house electrical power, or instrument air to the evaporator system. With the long startup times involved in restarting the unit, it may be economically advantageous to have redundant systems in place for electricity and instrument air.

- Testing pH control system
  It was mentioned that a good method to test the pH control system is needed. Placing the pH probe in a few solutions of differing pH values, as described to us by plant personnel, will check the control action, but not necessarily the controllability of the system as a whole. If nitric acid can be used on a temporary basis, it could be used to test the controllability of the pH adjustment system by feeding domestic water to the unit and putting a set point of ~pH 6 on the pH controller. This test would test the controllability of the system as a whole, with all parts of the system in use. The resulting water could be

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disposed of in the plant sewage system. However, this test requires the use of nitric acid on site, and it appears that this is not feasible at this time.

- Testing and Calibration of I&C systems
  Confirmation of instrumentation and alarm inputs has been addressed in the Rocky Flats test procedures. Calibration of instrumentation is proceeding but was not complete as of the time of our visit on May 24–28, 1993. Calibration of pH probes, pressure indicators, and thermocouples was complete. Almost all conductivity elements had been calibrated. Pressure switches, flow meters, and density probes were to be calibrated the following week.

- Safety Hazard
  A pipe-rack I-beam between Generator 3 and Building 910 is mounted so that persons who are more than about 6 ft tall may hit their heads on the exposed beam. This should be reviewed.

COMMENTS ON SPECIFIC REPORTS AND PROCESS

Process Qualification Procedure for Building 910 Portable Waste Treatment Evaporator, April 30, 1993.

- Acceptance Criteria
  Section 8.0 ACCEPTANCE CRITERIA reads (in part):
  "Evaporators shall be operated using Pond and Mod Tank water -- It shall be demonstrated that the evaporators can produce acceptable quality distillate, less (than) 150 μmhos, at an acceptable rate, 750 gph."

  This criteria statement is incomplete because it does not define values (or range of values) expected for the concentration of product concentrate (brine), nor for the amount of heat from natural gas required per unit of throughput (heat rate, Btu/lb feed).

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The *feed rate* is supposed to be 750 gph. The *distillate* rate has not been specified, but will be a function of the feed concentration and flow rate and of the concentration of the product concentrate (brine). Table 1 from Ref. 5 of the Heat and Mass Balances document list gives flow rates and concentrations of the product streams for a blowdown brine concentration of 400,000 ppm with 6600 lb/hour of feed at three different concentrations.

Table 1

Feed Water Conc, ppm	3,600	7,600	13,000
Concentrate to MEMS, ppm	9,778	20,642	33,309
Blowdown brine flow, lb/hr	60	125	215
MEMS Distillate flow, lb/hr	2,370	2,305	2,215
VC Distillate flow, lb/hr	4,170	4,170	4,170
Total Distillate flow, lb/hr	6,540	6,475	6,385

The heat rates in the two most recent Licon flow diagrams References 5 and 6 of the Heat Balance List were 277 Btu/lb and 238 Btu/lb, respectively, (18.3 and 15.75 therms per hour for 750 gal/day). None of these values are from actual tests, so it remains for the forthcoming tests to observe the actual gas consumption. The smaller values apply to the Florida tests when the feed temperatures were high.

APPENDIX

Evaporator Operation Data Sheets (pp. 14-17)

MEMS CONTROL PANEL DATA POINTS (27 POINTS), p. 14

- Each item listed should include instrument number and units.
- Item 25, Density, presently reads hertz, which is a function of density. If possible "hertz" should be converted to conventional density units within the instrumentation and read as such at the panel board.
- Item 26, "Cond. CT", should have a more understandable name, such as "Concentrate conductivity" ?)

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MEMS INDICATOR PANEL DATA POINTS (13 items), p. 15

- Should include instrument number and units
- Space should be provided to record both instantaneous and totalized values for flow and integrated flow (gpm and total gallons) for all (FQI) readings.

VC CONTROL PANEL DATA POINTS (27 POINTS), p. 16

- Instrument number and units needed for each item

VC Indicator Panel Data Points (8 items, presently), p. 17

- Instrument number and units needed
- A new flow indicator (FI) number should be assigned for the new feedline from the discharge of the regenerative heater (E4005) into the side of EV1001 (Evaporator vessel), and included as item "FI-nnn Feed Water (Side)".

Item called PRESSURE doesn't appear to be recorded in the tests thus far. What is it for?

MISC. DATA

GENERATOR DATA POINTS

- Flow rate (of what), gpm?
- Add a reading for totalized flow of natural gas.

FACTORS THAT WILL REDUCE THROUGHPUT

- Scale formation

  Remedy--descale when throughput is reduced by a given factor (10 to 20%) by reducing pH to about 3.5 using sulfamic acid. Perhaps the nitric acid system could be used with sulfamic acid, in the absence of other provisions for descaling.

  Avoid frequent shut downs because scaling tendency is greatest during negative temperature swings.

- Dissolved gas in feed

  Dissolved gas in feed more than likely is a real problem when high alkalinity pond feed is neutralized by nitric acid. There is no provision for venting noncondensibles from VC500. It would be advisable to install a vent line from just upstream of MV2004 at the top of the distillate plenum of VC500 to the vent line from the Stage 2 condenser (CD1010) at MV2024, sized to vent up to about 5% of the steam that enters the tube bundle of VC500.

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- **Low feed water temperature**
  It has been demonstrated at Rocky Flats in tests using domestic water that distillate production is about 20% lower using feed water at about 50°F than the rates observed at higher temperatures (80° to 90°F, Ref. 4, Miscellaneous Documents, and undocumented data from System 1 on April 21, 1993, and from System 2 on March 31, 1993).

  Feed water temperatures in the Florida tests were in the range 92° to 106°F, and the distillate outputs were 793, 728, and 760 gallons/hour, respectively in Systems 1, 2, and 3. Nominal feed rates of domestic water were 6600 lb/hour. The existing feed heater arrangement using E6004 is almost worthless. If reduced throughputs under winter conditions are unacceptable, a new feed heater should be installed, possibly using engine jacket water as heat source--about 300,000 Btu/hour would be required.

- **High concentration Boiling point elevation (BPE)**
  BPE losses at the expected concentrations may result in about a 10% reduction in throughput from the values observed using domestic water as feed.

- **High cooling water temperatures**
  If the cooling tower proves inadequate to maintain the cooling tower sump temperature below, say, 90°F, the flashing range in MEMS will be reduced because of higher vapor temperature in the reject condenser, which will reduce the MEMS output of distillate, and increase fuel requirements.

- **Frequent shutdowns**
  Frequent shutdowns will reduce plant availability and increase unproductive use of natural gas, and perhaps increase fouling rates.

If you have any questions, please contact us.

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ATTACHMENT DOCUMENT LIST

PROCEDURES

1. *Component Check-out and System Operation Test Procedure for Building 910 Portable Waste Treatment Evaporator,* Feb. 12, 1993.
2. 4-22PEP-910-004 *Evaporator Feed System,* April 20, 1993.
3. 4-22PEP-910-009 *Concentrate System,* April 1, 1993
4. 4-22ARP-101-CIA-1108 *Ponds Leak Detector Alarm Response,* April 15, 1993.
5. 4-22ARP-101-ANN *Building 910 Annunciator Panel Alarm Response Procedures*
6. 4-22ARP-101-AA910 *Building 910 Alarm Annunciator Panel Alarm Response Procedures*
7. 4-22ARP-101-VC *Building 910 Unit Evaporators Vapor Compressor (VC) Alarm Response Procedures*
8. 4-22ARP-101-MEMS *Building 910 Unit Evaporator Multiple Effect Multiple Stage (MEMS) Alarm Response Procedures*
9. 4-22ARP-101-MCP *Building 910 Main Control Panel Alarm Response Procedures*
10. *Temporary Modular Tank Installation SO & CC Test,* August 4, 1992.
11. *Component Check-out and System Operation Test Procedure for Building 910 Portable Waste Treatment Evaporator,* February 12, 1993.
12. *Process Qualification Procedure for Building 910 Portable Waste Treatment Evaporator,* April 30, 1993.

MISCELLANEOUS

1. *Rocky Flats Plant Solar Evaporation Ponds Remediation Project (OU-4) Design Review Report,* April 15, 1993.
2. *Standard for Piping Material Specifications,* April 31, 1993.
3. *Test Plan for the Bldg. 910 Evaporators and Associated Tanks,* J.D. McKaig, December 17,

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1992.

4. *Summary of Results of LICON Start-up of 910 Evaporators,* J.D. McKaig, February 11, 1993.

HEAT AND MASS BALANCES

1. *TRANSVAP 750--Aquavap VC500 Heat Balance,* October 4, 1990.

2. *Heat Balance for Average Conditions--TRANSVAP 750 MEMS 704 Rated 250 GPH,* October 5, 1990.

3. *TRANSVAP 750 Heat Balance Proposed for Rocky Flats*, October 4, 1990.

4. *Engine Cooling Water Arrangement (for two engines running and one standby)*, October 10, 1990.

5. Flow Diagram TRANSVAP 750, Rev. 2 (with heat balance), March 14, 1991.

6. *Licon Transvap 750 Total Energy System Evaporators Heat Balances During Acceptance Tests*, Bob McElroy, March 25, 1992.

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Rocky Flats Plant Building 910 Evaporators Precursory Failure Modes and Effects Analysis

Performance Engineering
Dirk D. Holt

June 4, 1993

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INTRODUCTION

This analysis examined the Rocky Flats Plant Building 910 Evaporators. A functional flow block diagram of the process is shown in Figure 1. The portions of the process that were examined in this analysis are presented in solid boxes while the portions that were not examined are presented in dashed boxes. Please note that an arrow from one box to another represents the transfer of something from that subsystem to the other - it does not indicate the number of items transferred or the number of pathways for transfer.

OBJECTIVES OF ANALYSIS

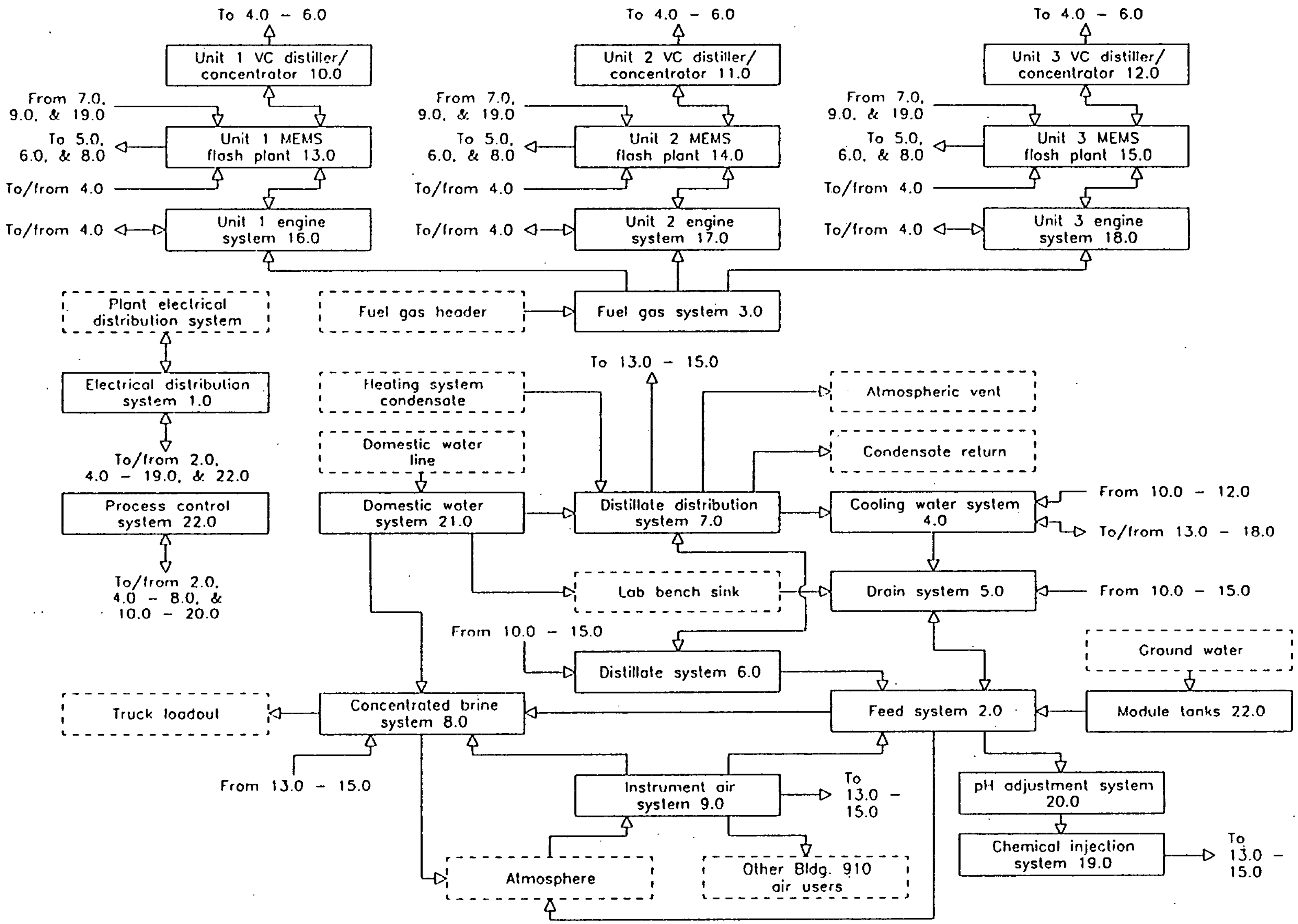
This analysis is concerned with the failures of the Rocky Flats Plant Building 910 Evaporators. The failures of concern are 1) single failures and/or combinations of two failures that could lead to deposition of feed water into the raw water or condensate systems, and 2) failures that could lead to excessive down time (i.e. several months). This analysis considered common mode failures for the Building 910 evaporators utilities - the electrical distribution system (1.0), the fuel gas system (3.0), the instrument air system (9.0), the domestic water system (21.0), and the process control system (22.0). The remaining sections of the Building 910 evaporators were considered at a subsystem level of inquiry.

RESULTS OF ANALYSIS

There are two results to this analysis. The first is the failure modes of concern for the Building 910 evaporators. This have been noted in the analysis. Most of these failure are rare due the scarcity of the failure(s) occurring. However, a few of the failure of concern are either due to operation or can affect the entire plant. The operational failure modes of concern are the opening of the valves MV7005, 1CCV353, 2CCV353, or 3CCV353. The failure that can affect the entire plant is leakage from the distillate into the domestic water supply.

The second result of this analysis is its usage as a screening document for areas requiring more analysis. Those subsystems that do not appear to have single point failure modes would not benefit with a failure modes and effects analysis at the component level. Those with single point failure modes would benefit with a failure modes and effects analysis at the component level, since this would reveal which components would be need backup.

Figure 1. Rocky Flats Plant Building 910 Evaporators Functional Flow Block Diagram.



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Date: June 4, 1993

Prepared by: D. D. Holt

Number	Item	Failure Mode	Effect on System	Remarks
1.0	Electrical distribution system	Generator or transformer failure	May result in loss of electrical power to the train	Possible single point failure mode of concern - may shut down the train until replaced or repaired (if possible)
2.0	Feed system	There are no known failure modes of the equipment that can result in one or more of the trains being down for months or mixing distillate with concentrate		
3.0	Fuel gas system	Equipment leakage	May result in an explosion at an ignition source	Probable single point failure mode - explosion probably will shut down one or more trains for months
4.0	Cooling water system	Loss of cooling	Requires either 1) drain valve fails open, 2) cold temperatures and failure of temperature sensor, temperature switch, or heater, 3) equipment leaks and loss of coolant makeup (one of three check valves fail closed, air operated valve fails closed, or loss of air supply), or 4) cooling tower pump(s) failure(s)	Drain valve failing open and/or cooling tower pump(s) failure(s) are single point failure modes of concern
5.0	Drain system	There are no known failure modes of the equipment that can result in one or more of the trains being down for months or mixing distillate with concentrate		
6.0	Distillate system	Equipment leakage	Spill of distillate product; SOP requires that the spill be treated as if it were feed material; SOP requires that the process trains be shut down until the leaks are stopped or avoided	The affected section may not be able to be isolated; the always-empty-third-tank will not be able to receive product from the affected section
		Cross leakage between concentrate and distillate	Loss of distillate product and creation of diluted concentrate product - requires: 1) distillate AOV(s) leakage from process stream(s) to air line(s), 2) loss of air pressure, and 3) bleed from air line(s) through concentrate diaphragm(s) and/or AOV(s) to process stream(s)	

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Date: June 4, 1993

Prepared by: D. D. Holt

Number	Item	Failure Mode	Effect on System	Remarks
7.0	Distillate distribution system	Equipment leakage	Spill of distillate product; SOP requires that the spill be treated as if it were feed material; SOP requires that the process trains be shut down until the leaks are stopped or avoided	
		Cross leakage between concentrate and distillate	Loss of distillate product and creation of diluted concentrate product - requires: 1) distillate AOV(s) leakage from process stream(s) to air line(s), 2) loss of air pressure, and 3) bleed from air line(s) through concentrate diaphragm(s) and/or AOV(s) to process stream(s)	
		Leakage from distillate into domestic water supply	Contamination of domestic water supply with distillate product - requires common failure of three (3) check valves and AOV 1069 either fails or commanded open	Failure mode of concern that can affect the entire plant
8.0	Concentrated brine system	Equipment leakage	Spill of concentrate product; SOP requires that the process trains be shut down until the leaks are stopped or avoided	
		Cross leakage between concentrate and distillate	Loss of concentrate product and production of off-spec distillate product - requires: 1) concentrate diaphragm(s) leakage and/or AOV(s) leakage from process stream(s) to air line(s), 2) loss of air pressure, and 3) bleed from air line(s) through distillate AOV(s) to process stream(s)	
		Leakage from domestic water supply into concentrate	Dilution of concentrate product - requires leakage through or improper opening of hand valve MV7005	Single point operation or failure mode of concern
9.0	Instrument air system	There are no known failure modes of the equipment that can result in one or more of the trains being down for months or mixing distillate with concentrate - the equipment can be replaced by commercial air compressors		

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Date: June 4, 1993

Prepared by: D. D. Holt

Number	Item	Failure Mode	Effect on System	Remarks
10.0	Unit 1 vapor/compressor distiller/concentrator	Pump seal(s) cross leakage between concentrate and distillate	Either 1) loss of distillate product and creation of diluted concentrate product or 2) loss of concentrate product and production of off-spec distillate product	Single point failure mode of concern
		Feed heater cross leakage between concentrate and distillate	Either 1) loss of distillate product and creation of diluted concentrate product or 2) loss of concentrate product and production of off-spec distillate product	Single point failure mode of concern
		Regenerative heater cross leakage between concentrate and distillate	Either 1) loss of distillate product and creation of diluted concentrate product or 2) loss of concentrate product and production of off-spec distillate product	Single point failure mode of concern
		Distillate tank drainage valve leakage to sump	Spill of distillate product; SOP requires that the spill be treated as if it were feed material; SOP requires that the process train be shut down until the leak are stopped or avoided	Single point failure mode of concern
		Distillate tank drainage spillage to sump	Requires failure or operator disregard of the level high alarm and operator disregard or forgetting of distillate product removal; spill of distillate product; SOP requires that the spill be treated as if it were feed material; SOP requires that the process train be shut down	
11.0	Unit 2 vapor/compressor distiller/concentrator	Failure modes and effects analysis is similar to 10.0		
12.0	Unit 3 vapor/compressor distiller/concentrator	Failure modes and effects analysis is similar to 10.0		

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Date: June 4, 1993

Prepared by: D. D. Holt

Number	Item	Failure Mode	Effect on System	Remarks
13.0	Unit 1 multi-effects multi-stages flash plant	Pump seal(s) cross leakage between concentrate and distillate	Either 1) loss of distillate product and creation of diluted concentrate product or 2) loss of concentrate product and production of off-spec distillate product	Single point failure mode of concern
		Solenoid operated valve 1CCV353 opens	Loss of concentrate product and production of off-spec distillate product	Single point operation or failure mode of concern
		Feed heater cross leakage between concentrate and distillate	Either 1) loss of distillate product and creation of diluted concentrate product or 2) loss of concentrate product and production of off-spec distillate product	Single point failure mode of concern
		Condenser(s) cross leakage between concentrate and distillate	Either 1) loss of distillate product and creation of diluted concentrate product or 2) loss of concentrate product and production of off-spec distillate product	Single point failure mode of concern
		Concentrate heater cross leakage between concentrate and distillate	Either 1) loss of distillate product and creation of diluted concentrate product or 2) loss of concentrate product and production of off-spec distillate product	Single point failure mode of concern
		Distillate tank drainage valve leakage to sump	Spill of distillate product; SOP requires that the spill be treated as if it were feed material; SOP requires that the process train be shut down until the leak are stopped or avoided	Single point failure mode of concern
		Vapor/compressor feed leakage to distillate	Requires check valve TV-436 MV2035-1 to fail open and valve 1CCV488B to fail open	
		Vapor suppression failure	Will result in damage to the generator and therefore loss of electrical power to the train	Single point failure mode of concern - will shut down the train until replaced or repaired (if possible)
14.0	Unit 2 multi-effects multi-stages flash plant	Failure modes and effects analysis is similar to 13.0		

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Prepared by: D. D. Holt

Number	Item	Failure Mode	Effect on System	Remarks
15.0	Unit 3 multi-effects multi-stages flash plant	Failure modes and effects analysis is similar to 13.0		
16.0	Unit 1 engine system	Equipment leakage	Requires line leakage or leakage through the two control valves; may result in an explosion since ignition sources exist in the compartment	Probable single point failure mode - explosion probably will shut down one or more trains for months
		Aftercooler failure	May result in overheating and therefore damage of the engine	Possible single point failure mode of concern
17.0	Unit 2 engine system	Failure modes and effects analysis is similar to 16.0		
18.0	Unit 3 engine system	Failure modes and effects analysis is similar to 16.0		
19.0	Chemical injection system	There are no known failure modes of the equipment that can result in one or more of the trains being down for months or mixing distillate with concentrate		
20.0	pH adjustment system	There are no known failure modes of the equipment that can result in one or more of the trains being down for months or mixing distillate with concentrate		
21.0	Domestic water system	There are no known failure modes of the equipment that can result in one or more of the trains being down for months or mixing distillate with concentrate		
22.0	Process control system	PLC failure	Loss of production until repaired or replaced	Possible single point failure mode of concern

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